Spreader grafts: functional or just aesthetical?*

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Abstract

Objective: Spreader grafts are commonly used in rhinoplasty to achieve an aesthetic improvement of the nose or a functional improvement of the nasal airway. Currently, the aesthetic role of spreader grafts is well established. The functional effect of these grafts, however, has been controversial due to the lack of studies clearly demonstrating an increase on nasal airflow assigned to spreader grafts. The purpose of this study is to evaluate the effect of spreader grafts on nasal breathing.

Methods: Nasal breathing of 72 consecutive patients undergoing rhinoplasty was evaluated by measuring peak nasal inspiratory flow (PNIF) before surgery and six months after surgery.

Results: The mean preoperative PNIF of the 72 patients included in this study was 79.44 l/min and the mean postoperative PNIF was 110.42 l/min ($p < 0.001$).
In 37 patients of this study no spreader grafts were used. In this group of patients the mean PNIF values changed from 73.24 l/min before surgery to 99.46 l/min after surgery. In the group of 35 patients in whom spreader grafts were used the mean PNIF values changed from 86.00 l/min before surgery to 122.00 l/min after surgery. The increase in the mean PNIF value after rhinoplasty was slightly higher in the group of patients with spreader grafts than in the group of patients without spreader grafts. The difference in the postoperative increase of PNIF between these two groups of patients, however, is not statistically significant.

Conclusions: This study suggests that patients undergoing rhinoplasty have a statistically significant improvement in nasal breathing after surgery. However, patients receiving spreader grafts in a non-randomized way do not have statistically significant greater benefit than those who do not.

Key words: spreader grafts, rhinoplasty, nasal breathing, peak nasal inspiratory flow, PNIF

Introduction

Spreader grafts are commonly used in rhinoplasty, to achieve an aesthetic improvement of the nose or a functional improvement of the nasal airway. These grafts were first described in 1984 by Sheen as a way to prevent long term sequelae in the middle vault of the nose after reduction rhinoplasty [(1)]. The use of spreader grafts may be particularly important in patients with short nasal bones, weak upper lateral cartilages and thin skin. In these patients, as well as in patients with narrow and tall noses, lowering the nasal dorsum may lead to destabilization of the middle third of the nose, eventually leading to long term complications. Aesthetic sequelae, such the inverted-V deformity or the hour-glass deformity may arise, as may functional consequences, due to nasal airway obstruction secondary to static or dynamic malfunction of the internal nasal valve.

There is a general consensus among facial plastic surgeons regarding the stabilizing effect of spreader grafts on the middle third of the nose, as these grafts reinforce the cartilaginous structural support and provide strength to this segment of the nose. Spreader grafts are the most commonly used surgical tool to rebuild the middle third of the nose or to stabilize the middle vault and prevent aesthetic and functional long term sequelae after a reduction rhinoplasty.

Spreader grafts are also often used as a stent for straightening the dorsal septum, in cases of high septal deviations. The aesthetic modification of the middle third of the nose achieved by using spreader grafts is well known, as these grafts lateralize the upper lateral cartilages and, therefore, add some volume to the lateral wall of the nasal pyramid. Spreader grafts are often used for smoothing the aesthetic brow-tip lines in cases of asymmetry of the nose, for assisting to straighten a crooked nose and for widening a narrow middle third of the nose.

The effect of the spreader grafts on improving nasal breathing, however, is not unanimously recognized and several studies failed to demonstrate their efficacy for this purpose. The internal nasal valve is the narrowest segment of the nasal airway, being responsible for up to two thirds of the total resistance of the nasal cavities to the airflow. It has been demonstrated that spreader grafts increase the cross-sectional area of the internal nasal valve [2-4] and therefore should increase nasal airflow, particularly in cases of static narrowing of the internal nasal valve. Spreader grafts, however, have no effect on the nasal valve angle [5], unless other surgical techniques, such as a flaring suture of the upper lateral cartilages, are used concomitantly [2,5]. Spreader grafts also have a limited effect on increasing rigidity to the lateral wall of the nose and, therefore, may be unable to improve nasal airflow in cases of dynamic obstruction of the internal nasal valve.

In a clinical consensus statement recently published a group of experts from the American Academy of Otolaryngology stated that despite the lack of evidence for the efficacy of surgical treatment of internal nasal valve obstruction, most studies do suggest a strong benefit from surgery [6]. There is, however, a deficiency in studies using objective measures to evaluate nasal airflow for assessing the efficacy of surgical treatment of internal nasal valve obstruction [6,7].

The nasal airflow of 72 consecutive patients undergoing rhinoplasty was evaluated by measuring peak nasal inspiratory (PNIF) flow before and six months after surgery. The surgical techniques used in each of these patients were individually tailored according to the unique nasal morphology of each patient and therefore the change in nasal airflow achieved by surgery cannot be assigned to a specific surgical technique or modification. Nevertheless, we compared PNIF measurements taken from the group of 35 patients in whom spreader grafts were used to PNIF measurements of he group of 37 patients in whom spreader grafts were not used.

Materials and methods

Patients

Seventy two consecutive patients undergoing rhinoplasty from March 2009 to April 2010 have been evaluated by measuring the peak nasal inspiratory flow (PNIF) before surgery and six months after surgery. Two other patients that underwent rhinoplasty in this period were not included in this study as their postoperative PNIFs have not been evaluated.

This group of patients included 38 men and 34 women, ranging from 16 to 58 years old. Patients with no aesthetical concerns and in whom septal deviation or turbinates hypertrophy was recognised as the cause for nasal obstruction were offered a septoplasty (without rhinoplasty) or turbinates reduction and were not included in this study.

Fifty seven cases in this study were primary rhinoplasties and 15 were revision rhinoplasties. Twenty nine patients had a pure aesthetic motivation for undergoing surgery, whereas 43 patients also had complaints of nasal obstruction. An open approach was used in 48 patients, a delivery approach in 3 patients, a non-delivery approach in 11 patients and an intercartilaginous approach (without tip work) in 10 patients.

Each of the 72 patients included in this study was individually assessed regarding nasal deformities and nasal obstruction. A surgical plan was individually tailored according to this evaluation, which may have included any surgical technique considered useful to address the specific nasal deformities identified in each individual. In 46 patients septoplasty was considered necessary to straighten the septum and was performed at the time of rhinoplasty. In 23 of the patients with septoplasty spreader grafts were also used, in 23 patients no spreader grafts were used. Turbinate reduction was not conducted in any patient of this study; in every case inferior turbinate outfracture was performed.

Spreader grafts were used in 35 patients of this study. Flaring sutures, suspension sutures or any other surgical technique designed for widening the internal nasal valve angle were not used in this study. In 26 of the 35 patients in whom spreader grafts were used no other modification of the middle third of the nose was performed. Spreader grafts were used, in these patients, for aesthetic reasons, for widening the middle third of the nose, for widening the internal nasal valve, or as a stent for straightening a high septal deviation.

In 9 of these 35 patients significant lowering of the nasal dorsum was performed for aesthetic reasons and spreader grafts were used for providing long-term support to the middle third of the nose. Less significant dorsal reduction was also performed in other patients of this study, but spreader grafts were not considered necessary and, therefore, were not used.

PNIF measurements

PNIF was measured with a portable Youlten peak flow meter (by Clement Clark International), using a size appropriated facial mask. The size of the mask was chosen to fit tightly on the patient´s face without touching the nose. The measurements were recorded while the patients were sitting and asked to

Table 1. Descriptive statistics of the patient's recorded variables and type of surgery performed (n = 72).

	n (%)
Gender	
Female	34 (47.2%)
Male	38 (52.8%)
Age	
(years) mean (SD)	31.74 (10.74)
Spreader Grafts	
With spreader grafts	35 (48.6%)
No spreader grafts	37 (51.4%)
Revision	
Primary Rhinoplasty	57 (79.2%)
Revision Rhinoplasty	15 (20.8%)
Approach	
Endonasal Approach	24 (33.3%)
Open Approach	48 (66.7%)
Septoplasty	
Without Septoplasty	26 (36.1%)
With Septoplasty	46 (63.9%)
Functional complaints	
No complaints (aesthetic)	29 (40.3%)
Complaints (nasal obstruction)	43 (59.7%)
Unilateral spreader	
No	65 (90.3%)
Yes	7 (9.7%)

inhale as hard as they could after a full expiration and keeping the mouth closed. Three measurements were taken from each patient preoperatively and six months after surgery, with the highest value of the three measurements recorded as preoperative and postoperative PNIF. Topical medication was not used before any of the measurements, and isotonic saline sprays were not used at least two weeks before the postoperative measurements.

Statistical analysis

Descriptive statistics and nonparametric (Wilcoxon and Mann-Whitney) tests were used as required. Although normality could be assumed for some of the variables, a conservative uniform nonparametric approach was adopted throughout the analysis.

Table 2. Descriptive statistics for the PreopPNIF and PostopPNIF values.

	Mean	95%CI	SD	Min	Max	P25	Median	P75
Preop PNIF	79.44	70.86 88.03	36.54	30	200	50	75	100
Postop PNIF	110.42	100.32 120.51	42.97	40	230	80	100	140

Patient characteristics are presented as frequencies and percentages for categorical data, and as means or medians, standard deviation (SD), first quartile (P25), third quartile (P75) and minimum (Min) and maximum (Max) values for continuous variables. 95% confidence intervals (95%CI) for the mean value were calculated and presented whenever appropriate.
A significance level (α) of 5% was considered throughout the analysis. All data were entered and analyzed using the Statistical Package for the Social Science (IBM SPSS, version 21). The power of the tests performed was obtained with the statistical software R [8] using the "pwr" package [9]. The effect sizes used in the formulas to calculate the power to detect the differences were used according to Cohen [10].

Results

A total of 72 patients underwent rhinoplasty surgery. The patient's mean age was 31.74 years (SD, 10.74) ranging from 16 to 58 years. Thirty-eight patients (52.8%) were male and 34 (47.2%) were female. Further patient's surgery characteristics and descriptive statistics are presented in Table 1.
The PNIF values were registered before (PreopPNIF) and after (PostopPNIF) surgery. Table 2 provides descriptive statistics for both these variables where it can be observed that both the mean and median PNIF values have increased after surgery. Being the mean preoperative PNIF equal to 79.44 l/min and

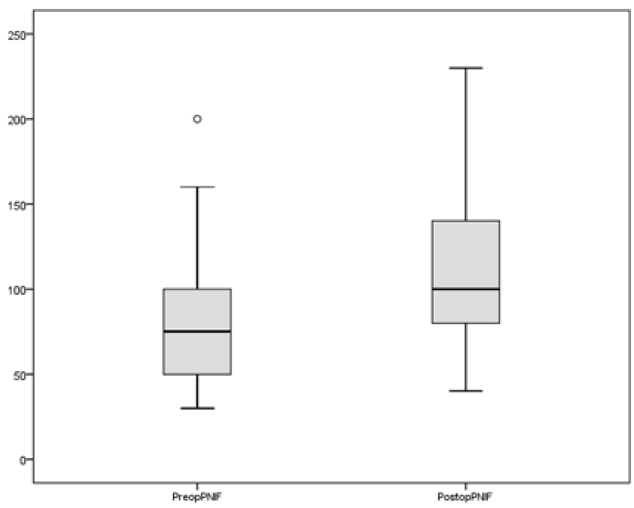

Figure 1. Boxplots for Preop and Postop PNIF values.

Table 3. Descriptive statistics for the PreopPNIF and PostopPNIF values according to Spreader Grafts use.

	Mean	SD	Min	Max	P25	Median	P75
PreopPNIF							
No spreader	73.24	28.87	30	150	50	70	90
Spreader	86.00	42.65	30	200	50	80	120
Postop PNIF							
No spreader	99.46	36.81	40	180	80	90	120
Spreader	122.00	46.39	50	230	80	130	160

Table 4. Descriptive statistics for the relative increase percentages and differences in PNIF values when comparing before and after surgery.

	Mean	95% CI	SD	Min	Max	P25	Median	P75
Relative Increase %	53.69	39.28 68.11	61.34	-50	300	8.27	40.83	97.92
Differences	30.97	23.07 38.87	33.62	-40	110	10	30	50

Table 5. Descriptive statistics for the relative increase percentages and differences in PNIF values according to Spreader Grafts use.

	Mean	SD	Min	Max	P25	Median	P75
Relative Increase %							
No spreader	46.65	54.46	-50	166.67	3.33	37.5	81.75
Spreader	61.13	67.88	-37.5	300	10	42.86	100
Differences							
No spreader	26.22	31.39	-40	110	5	30	45
Spreader	36.00	35.58	-30	110	10	30	60

Table 6. Descriptive statistics for the Relative Increase % and Differences values according to Septoplasty.

	Mean	SD	Min	Max	P25	Median	P75
Relative Increase%							
no septoplasty	42.81	66.55	-44.44	300	5.36	31.67	56.67
with septoplasty	59.84	58.05	-50.00	166.67	9.42	52.27	100
Differences							
no septoplasty	25.00	29.83	-40	90	7.5	30	42.50
with septoplasty	34.35	35.44	-40	110	10	40	60

the mean postoperative equal to 110.42 l/min, this implies an increase of around 39% in peak nasal inspiratory flow achieved by rhinoplasty in the cohort of patients included in this study. The distribution of the PNIF values before and after surgery can be observed on the boxplots depicted in Figure 1. Even though the boxplot of PostopPNIF is slightly higher than the PreopPNIF values, they overlap for most of the range considered. However, a statistical significant difference (Wilcoxon test with $p < 0.001$, power = 0.80) was detected between the pre and post surgery PNIF values.

Interest focused on investigating whether the use of spreader grafts would increase the PNIF values in the post-operative stage more significantly than in the group of patients in whom spreader grafts were not used.
Table 3 includes descriptive statistics for the variables PreopPNIF and PostopPNIF according to the use, or not, of spreader grafts. In 37 patients no spreader grafts were employed, the remaining 35 patients received spreader grafts (see Table 1 for these frequencies). In the group of patients who did not have spreader grafts the mean PNIF values changed from 73.24 l/min before

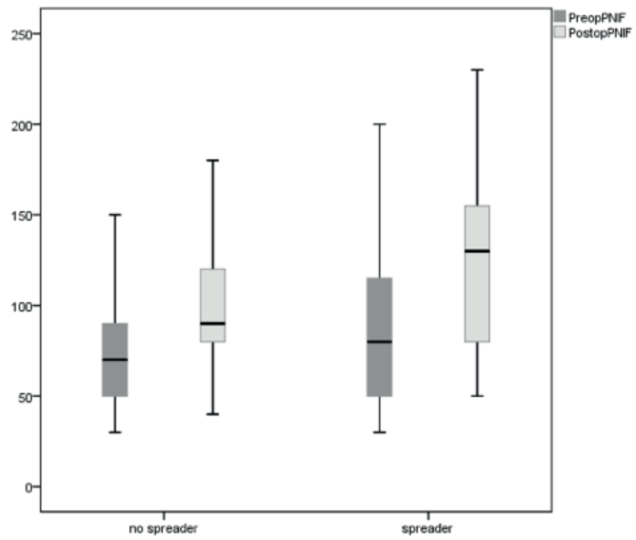

Figure 2. Boxplots for Preop and Postop PNIF values in the groups of patients with and without spreader grafts.

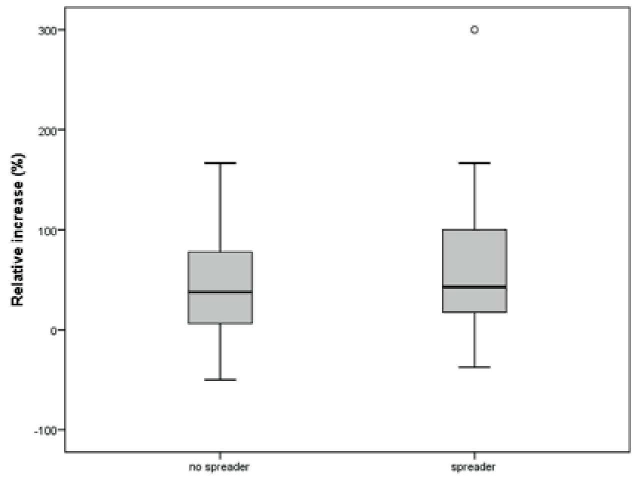

Figure 3. Boxplots of relative increase percentages (before and after surgery PNIF values) according to Spreader Grafts use.

surgery to 99.46 l/min postoperatively, which represents an approximate 36% relative increase in PNIF achieved by surgery.
It is also noticeable that both the means and medians corresponding to the pre surgery PNIF values were higher on patients that were later assigned to spreader grafts (e.g. the mean PreopPNIF value is equal to 73.24 l/min for no spreader grafts and is equal to 86.00 l/min when spreader grafts were later employed). Equivalent conclusions can be taken from the observation of the four boxplots shown in Figure 2.
From observation of the boxplots in Figure 2 it is noticeable that the PNIF values have increased after both types of surgery, i.e. with and without spreader grafts use, being the increase with spreader grafts slightly higher than without spreader grafts. Furthermore, there is evidence of statistically significant (Wilcoxon test, $p < 0.001$) differences between the Postop and Preop PNIF values within each type of surgery, i.e. with and without spreader grafts employment (the powers obtained in the two tests were 0.89 and 0.98, respectively).
Equation (1) was used to obtain the percentages of relative increase in PNIF values after surgery from the corresponding Preop and Postop measures for each patient.

$$\text{Relative increase \%} = (\text{PostopPNIF} - \text{PreopPNIF}) / \text{PreopPNIF} \times 100 \qquad (1)$$

Equation (2) was employed to obtain the differences in PNIF values before and after the surgery.

$$\text{Differences} = \text{PostopPNIF} - \text{PreopPNIF} \qquad (2)$$

Equations (1) and (2) enabled the creation of two new variables that were used to assess a possible significant difference in the increase in PNIF values after the two types of surgery. Table 4 shows descriptive statistics for the percentage relative increase (Relative Increase %) and for Differences.
Table 5 depicts descriptive statistics for Relative Increase % and Differences according to the use of spreader grafts (i.e., according to the two types of surgery performed).
Within both variables there is an increase in mean value from no spreader grafts to spreader grafts use. An increase also occurs when considering the medians values for the percentage relative increase (Relative Increase %) from no spreader grafts to spreader grafts employment (i.e. 37.5 to 42.86). However, there is no change in the medians within the values of Differences with the use of spreader grafts or no spreader grafts (i.e. both medians equal to 30).
The boxplots of the values of Relative Increase % and Differences according to the use of spreader grafts are depicted in Figures 3 and 4, respectively.
Nonparametric exact Mann-Whitney tests showed that there were no statistically significant differences between the percentages of relative increase and between Differences values when assuming spreader grafts as the grouping variable, having obtained $p = 0.437$ and $p = 0.258$, respectively, with values of power equal to 0.17 and 0.23. Nonparametric exact Mann-Whitney test showed that there were no statistically significant differences between the percentages of relative increase when assuming Septoplasty as the grouping variable ($p = 0.139$, power = 0.20) (Figure 5). Table 6 depicts descriptive statistics according to simultaneously performing septoplasty.
The only statistically significant differences between values for *Differences* were found when variable *Approach* was used as a grouping variable, i.e. make the distinction between open or endonasal approaches ($p = 0.037$, power = 0.45) and among the

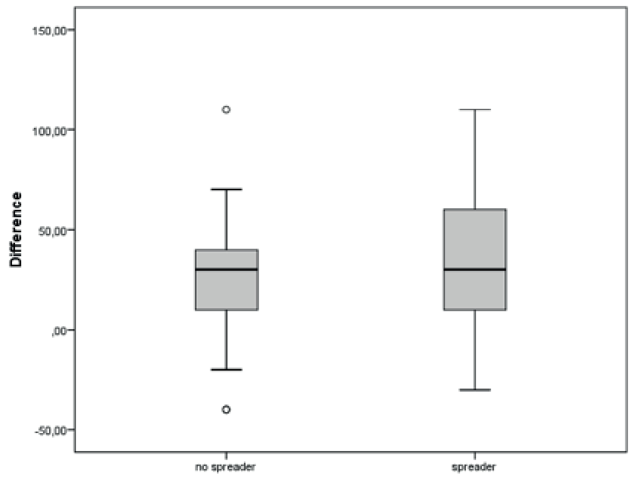

Figure 4. Boxplots of the values of PNIF differences according to Spreader Grafts use.

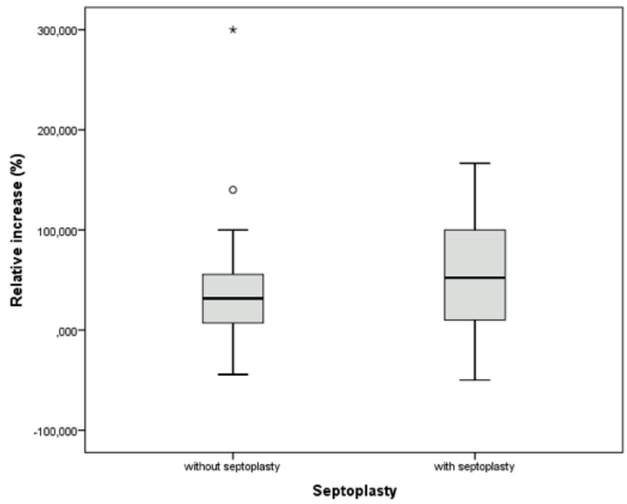

Figure 5. Boxplots of relative increase percentages (before and after surgery PNIF values) according to Septoplasty.

patient's gender (p = 0.020, power = 0.61).
Multiple regression models were fitted in order to clarify which variables were related to the relative increase percentages and to the *Differences* values. In the exploratory analysis, all variables which related to either of these with a p-value lower than 0.25 were selected to be included in the model. Consequently, *Approach* and *Gender* were considered as possible dependent variables associated with the relative increase percentages as the outcome variable. *Approach*, *Gender* and *Spreader Grafts* were selected for association with the outcome *Differences*. Equation (3) relates the association sought by multiple regression models:

Relative_Increase ~ Approach + Gender
Differences ~ Spreader Grafts + Approach + Gender (3)

However, when these two groups of variables were included, i.e. after adjusting the model, only *Gender* was found to provide a statistically significant association with both relative increase percentage and *Differences* (with p-values equal to 0.038 and 0.027, respectively).
Thus, even though there are statistically significant differences between PreopPNIF and PostopPNIF values for each category of the spreader grafts variable, no statistically significant differences were found between the two categories of spreader grafts use when either the percentages of relative increase PNIF values, or the differences between post and pre surgery PNIF values were considered.

Discussion

Spreader grafts are commonly used to prevent aesthetic and functional long term sequelae of rhinoplasty whenever surgery has addressed the middle vault of the nose. Spreader grafts are the most commonly used surgical technique in revision rhinoplasty cases to rebuild the middle third of the nasal pyramid and provide aesthetic and functional improvement of the nose. Spreader grafts are also often used in primary rhinoplasty cases to secure the upper lateral cartilages to the dorsal septum and stabilize the middle third of the nose, especially in patients prone to develop weakness in the middle third of the nose. Spreader grafts widen the middle third of the nose by lateralizing the upper lateral cartilages, therefore enlarging the internal nasal valve area. By doing so, theoretically they should improve the breathing capacity of this segment of the nasal airway, responsible for most of the nasal resistance to the airflow. This functional effect of spreader grafts, nevertheless, has been questioned, as several studies have not found evidence of significant functional improvement. According to this lack of evidence of the functional effect of spreader grafts, several other surgical techniques for improving nasal airflow through the internal nasal valve have been developed, such as the butterfly graft, the splay graft, the H-graft, the Z-plasty of the internal valve, the flaring suture and the suspension suture of the upper lateral cartilages. Some of these surgical techniques have tried to increase the cross-sectional area of the internal nasal valve while others have tried to reinforce the resistance of the internal nasal valve structures and, therefore, the capacity of the lateral nasal walls to better withstand the collapsing force generated during inspiration, according to Bernoulli´s Principle.
The effect of these surgical techniques on improving nasal airflow through the internal nasal valve, however, has not been clearly demonstrated, although having been suggested by several studies. In the present study nasal airflow changes achieved by rhinoplasty were assessed by comparing measurements of peak nasal inspiratory flow taken before and six

months after surgery in each of the 72 patients included in the study.

The measurement of peak nasal inspiratory flow has been shown to correlate with the dimensions of the nasal cavities [11] and with nasal airway resistance [12,13]. Some papers have not found peak nasal inspiratory flow to correlate with the subjective sensation of nasal breathing [14], while other studies have found a strong correlation [15-17]. PNIF measurement is a simple, straightforward test that is as sensitive as rhinomanometry [12,13] and acoustic rhinometry [18] for evaluating nasal obstruction. The reproducibility of peak nasal inspiratory flow has been demonstrated by several studies [16,19], making this method a reliable tool for assessing nasal patency.

An improvement of peak nasal inspiratory flow has been demonstrated after isolated septoplasty [20], but not after paranasal sinus surgery [21], suggesting that PNIF varies with an increasing capacity of the breathing area of the nasal cavities, but not with an increase of the free space of the paranasal sinus. Although there is a wide range for PNIF and although peak nasal inspiratory flow is also dependent on lower airway function, PNIF measurements taken from the same individual do correlate with changes in nasal patency, making peak nasal inspiratory flow a reliable and sensitive method for assessing changes in nasal airflow achieved by some form of treatment.

In the cohort of the 72 patients of the present study rhinoplasty was able to significantly improve the mean peak nasal inspiratory flow ($p<0.001$). Several different surgical techniques were used in the patients of this study and therefore the improvement in nasal airflow achieved by surgery cannot be assigned to a specific technique. Nevertheless, these findings suggest that rhinoplasty, by using and combining several remodelling techniques to reshape the nasal pyramid and bring the shape of the nose close to the "ideal" nasal pyramid, is able to improve nasal airflow. These findings are consistent with other studies that have found rhinoplasty to improve nasal breathing [22-25]. Most studies that have evaluated nasal airway obstruction after nasal surgery using patient-reported nasal obstruction scores, such as the NOSE scale or VAS, have also found statistically significant improvement of nasal obstruction after surgery [22,24,26].

Interestingly, in the cohort of patients included in the present study the simultaneous realization of septoplasty (in the same stage of rhinoplasty) did not seem to further increase the improvement in the nasal airflow achieved by rhinoplasty.

In the 72 patients of this study there was evidence of statistically significant increase of peak nasal inspiratory flow after rhinoplasty in the group of patients with spreader grafts as well as in the group of patients without spreader grafts ($p < 0.001$ in both groups). This improvement in nasal airflow after surgery was higher in the group of patients in whom spreader grafts were used. Nevertheless, the difference in increase after rhinoplasty between the two groups of patients (with and without spreader grafts) was not statistically significant either comparing the absolute increase or the relative increase in peak nasal inspiratory flow.

Poiseuille`s Law states that airflow resistance is inversely proportional to the 4th power of the radius of the space passed through. Therefore, a limited cross-sectional area of the internal nasal valve would produce a large airflow resistance, which would increase the velocity of the airflow passing through this narrow segment. According to Bernoulli`s Principle, this would lead to a raise on the negative pressure acting on the walls of the internal nasal valve, with a tendency to collapse and obstruction. In this setting, therefore, spreader grafts, by increasing the cross-sectional area of the internal nasal valve would raise the threshold for this cascade of events, turning less likely a dynamic nasal airflow obstruction, even without a significant effect on the stiffness of the walls of the middle third of the nose. This theoretical functional effect of spreader grafts, however, has never been demonstrated in living patients by clinical studies. The present study, conducted in 72 living patients, also failed to demonstrate this theoretical functional effect of spreader grafts.

This study suggests that patients undergoing rhinoplasty have a statistically significant improvement in nasal breathing after surgery. However, patients receiving spreader grafts in a non-randomized way do not have statistically significant greater benefit than those who do not.

Authorship contribution

RX: Study design, data collection, manuscript preparation, interpretation of results; SA-L, AP: Statistical analysis, manuscript preparation.

Conflicts of interest

No conflicts of interest exists.

References

1. Sheen J. Spreader graft: a method of reconstructing the roof of the middle nasal vault following rhinoplasty. Plast Reconstructive Surg 1984; 73:230-239.
2. Park S. The flaring suture to augment the repair of the dysfunctional nasal valve. Plastic Reconst Surg 1998; 101:1120-1122.
3. Weeks D, Walker D, Dutton J. Anatomical comparison of minimally invasive nasal valve procedures. Arch Facial Plast Surg 2012; 14:189-192.
4. Schlosser R, Park S. Surgery for the dysfunctional nasal valve: cadaveric analysis and clinical outcomes. Arch Facial Plast Surg 1999; 1:105-110.
5. Ballert J, Park S. Functional considerations in revision rhinoplasty. Facial Plast Surg 2008; 24: 348-357.
6. Rhee J, Weaver E, Park S, Baker S et al. Clinical consensus statement: diagnosis and management of nasal valve compromise. Otolaryn Head and Neck Surg 2010; 143:48-59.
7. Spielmann P, White P, Hussain S. Surgical techniques for the treatment of nasal valve collapse: a systematic review. Laryngoscope

2009; 119:1281-90.
8. R Core Team (2014). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/.
9. Stephane Champely (2012). pwr: Basic functions for power analysis. R package version 1.1.1. http://CRAN.R-project.org/package=pwr.
10. Cohen, J., 1988. Statistical Power Analysis for the Behavioural Sciences, 2nd ed. Hillsdale, NJ.
11. Kjaergaard T, Cvancarova M, Steinsvag SK. Relation of nasal airflow to nasal cavity dimensions. Arch Otolaryngol Head Neck Surg 2009; 135:565-570.
12. Holmstrom M, Scadding GK, Lund VJ, Darby YC. Assessment of nasal obstruction. A comparison between rhinomanometry and nasal inspiratory peak flow rate. Rhinology 1990; 28:191-196.
13. Jones AS, Viani L, Phillips DE, Charters P. The objective assessment of nasal patency. Clin Otolaryngol 1991; 16:206-211.
14. Pawar S, Garcia G, Kimbell J, Rhee J. Objective measures in aesthetic and functional nasal surgery: perspectives on nasal form and function. Facial Plastic Surg 2010; 26(4):320-327.
15. Fairley JW, Durham LH, Ell SR. Correlation of subjective sensation of nasal patency with nasal inspiratory peak flow rate. Clin Otolaryngol 1993; 18:19-22.
16. Cho S, Hauser R, Christiani DC. Reproducibility of Nasal Peak Inspiratory Flow among healthy adults. Chest 1997; 112:1547-1553.
17. JonesAS, Willatt DJ, Durham LM. Nasal airflow: resistance and sensation. J Laryngol Otol 1989; 103:909-911.
18. Ganslmayer M, Spertini F, Rahm F, Terrien MH, Mosimann B, Leimgruber A. Evaluation of acoustic rhinometry in a nasal provocation test with allergen. Allergy 1999; 54:974-979.
19. Harar RP, Kalan A, Kenyon GS. Assessing the reproducibility of nasal spirometry parameters in the measurement of nasal patency. Rhinology 2001; 39:211-214.
20. Marais J, Murray JA, Marshall I, Douglas N, Martin S. Minimal cross-sectional areas, nasal peak flow and patients´ satisfaction in septoplasty and inferior turbinectomy. Rhinology 1994; 32:145-147.
21. Lund VJ, Scadding GK. Objective assessment of endoscopic sinus surgery in the management of chronic rhinosinusitis: an update. J Laryngol Otol 1994; 108:749-753.
22. Zoumalan R, Constantinides M. Subjective and objective improvement in breathing after rhinoplasty. Arch Facial Plast Surg 2012; 14(6): 423-428.
23. Xavier R. Does rhinoplasty improve nasal breathing? Facial Plastic Surg 2010; 26:323-327.
24. Yoo S, Most S. Nasal airway preservation using the autospreader technique: analysis of outcomes using a disease-specific quality-of-life instrument. Arch Facial Plast Surg 2011; 13(4):231-233.
25. Constantinides M, Adamson P, Cole P. The long-term effect of open cosmetic septorhinoplasty on nasal air flow. Arch Otolaryng Head Neck Surg 1996; 122:41-45.
26. Most S. Analysis of outcomes after functional rhinoplasty using a disease-specific quality-of-life instrument. Arch Facial Plast Surg 2006; 8(5):306-309.

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